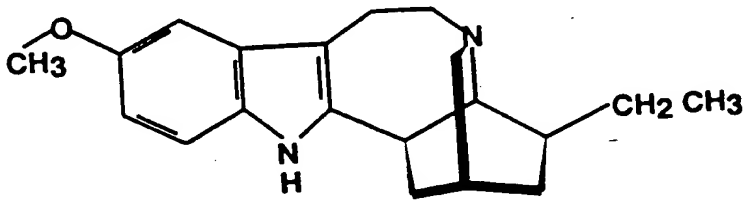
Noribogaine in the Treatment of Pain and Drug Addiction

Field of the Invention

The present invention is concerned with novel pharmaceutical compositions and novel treatment methods. In particular, the invention relates to novel methods for providing analgesia and to novel pharmaceutical compositions containing the drug noribogaine. The compositions particularly include those containing, in addition to noribogaine, one or more opioid antagonists. In addition, the present invention provides novel compositions and methods useful in treating patients for the symptoms associated with withdrawal from drug dependency or abuse.

Background of the Invention

Ibogaine is an indole alkaloid derived from *Tabernanth iboga*, a shrub of West Africa, and is used by indigenous people of that region in religious rituals. The structure of ibogaine has been determined and procedures for its synthesis have been reported (see, Buchi, *et al., J. Am. Chem. Soc. 88*:3099 (1966); Rosenmund, *et al., Chem. Ber. 108*:1871 (1975); and Huffman, *et al., J. Org. Chem. 50*:1460 (1985)). The chemical structure is as follows:



In 1956 Salmoiraghi and Page elucidated ibogaine's relationship to serotonin *(J. Pharm. and Exp. Ther. 120*(1):20-25 (1957)). About the same time Schneider published three important papers: "Potentiation Action of Ibogaine on Morphine Analgesia" (*Experiential 12*:323-24 (1956)); "Neuropharmacological Studies of Ibogaine: An Indole Alkaloid with Central Stimulant Properties ," *(Ann. of N.Y. Acad. Sci. 66*:765-76 (1957)); and "An Analysis of the Cardiovascular Action of Ibogaine HCl," (*Arch. Int. Pharmacodyn. 110*:92-102 (1957)). Dhahir published a review of the pharmacology and toxicology of ibogaine in his doctoral thesis, "A Comparative Study of the Toxicity of Ibogaine and Serotonin" (University

Microfilms International 71-25-341, Ann Arbor, Mich.). The thesis gives an overview of much of the work accomplished with ibogaine.

Additional studies of interest include: "The Effects of Some Hallucinogens on Aggressiveness of Mice and Rats " (Kostowski, *et al.*, *Pharmacology* 7:259-63 (1972)), "Cerebral Pharmacokinetics of Tremor-Producing Harmala and Iboga Alkaloids" (Zetler, *et al.*, *Pharmacology 7(4)*:237-248 (1972)), "High Affinity ^{3}H-Serotonin Binding to Caudate: Inhibition by Hallucinogenic and Serotonergic Drugs" (Whitaker, *et al.*, *Psychopharmacology 59*:1-5 (1978)); "Selective Labeling Of Serotonin Receptors by d-(^{3}H)Lysergic Acid Diethylamide in Calf Caudate" (*Proc. Natl. Acad. Sci., U.S.A. 75(12)*:5783-87 (1978)); and "A Common Mechanism of Lysergic Acid, Indolealkylamine and Phenethylamine Hallucinogens: Serotonergic Mediation of Behavioral Effects in Rats" (Sloviter, *et al., J. Pharm. Exp. Ther. 214(2)*:231-38 (1980)). More current work has been reported by Dzoljic, *et al.*, "Effect of Ibogaine on Naloxone-Precipitated Withdrawal Syndrome in Chronic Morphine Dependent Rats," (*Arch. Int. Pharmacodyn., 294*:64-70 (1988)).

Ibogaine administration has been reported to reduce the withdrawal symptoms associated with drug dependency and to alleviate drug cravings in addicts. It has been disclosed to be effective in the treatment of dependencies resulting from a wide range of drugs, including narcotics (U.S. 4,499,096); cocaine and amphetamines (U.S. 4,587,243); alcohol (U.S. 4,857,523); and nicotine/tobacco (5,026,697). In addition it has been reported to be effective in patients addicted to multiple drugs and drug combinations (5,152,994). Among the specific drug dependencies reportedly amenable to ibogaine treatment are heroin, cocaine, alcohol, nicotine, caffeine, amphetamine, desoxyephedrine, methadone and combinations thereof.

Other pharmacological agents that have been used in the treatment of certain types of drug addiction or dependency include naloxone and naltrexone. However, these agents typically fail to alleviate the often severe suffering that accompanies the drug withdrawal process and are generally ineffective in treating polydrug abuse or addiction. Thus, the prior art has failed to provide a completely satisfactory therapy for drug addiction or abuse and new agents and methods are clearly needed.

Summary of the Invention

In accordance with the present invention, surprising and unexpected properties of noribogaine have been discovered. This compound is known to be a metabolite of ibogaine and is chemically identified as 12-hydroxyibogamine. In particular, noribogaine has been found to be useful as a non-addictive analgesic agent and as a treatment for drug dependency or abuse. Pharmaceutical compositions of noribogaine can be combined with one or more known opioid antagonists to treat addiction such that withdrawal symptoms are substantially eliminated or, at a minimum, surprisingly reduced. Such compositions are conveniently prepared in unit dose form with one or more unit doses providing a therapeutically effective amount of active ingredient.

In its first aspect, the invention is directed to a method of alleviating pain in a patient by administering systemically noribogaine at a therapeutically effective dosage. In a preferred embodiment, administration is by means of a pharmaceutical composition in which noribogaine is the sole analgesic agent. In patients for whom opioid analgesics are contraindicated, noribogaine is administered systemically in an amount of effective to reduce or eliminate pain in the absence of any concomitant opioid analgesic therapy. In each case, the dosage of noribogaine administered to a patient should be between 0.1 and 100 mg per kg of body weight and, preferably, between 1 and 30 mg per kg of body weight.

The present invention also includes a method of treating a patient to alleviate pain by administering systemically noribogaine and one or more opioid antagonists, such that the respective amounts of noribogaine and antagonist are effective to reduce or eliminate pain. If desired, one or more opioid antagonists may also be administered to patients, with the preferred antagonist being naloxone, naltrexone or nalorphine, preferably at a concentration of between 0.15 mg and 0.5 mg for each mg of noribogaine administered. Although, the method is compatible with any route of administration, the transdermal route will generally be the most convenient.

The invention is also directed to a method for treating drug addiction (involving drug dependency or drug abuse) during withdrawal therapy by administering noribogaine to a patient at a dosage sufficient to reduce or eliminate one or more symptoms associated with withdrawal.

Such symptoms include nausea, vomiting, anxiety, abdominal cramps, muscle pain, chills and headache. In addition, noribogaine treatment decreases the drug cravings normally experienced by addicts after cessation of the self administration of the abused substance. Noribogaine is especially useful in the treatment of addiction to narcotics such as heroin and methadone. However, it is also useful in treating patients addicted to cocaine, alcohol, amphetamines and combinations of these drugs. It is preferred that the noribogaine be administered to patients suffering from drug dependance or abuse in conjunction with an opioid antagonist such as naloxone, naltrexone or nalorphine. The dosage of noribogaine should be as discussed above in conjunction with its use in the alleviation of pain. Again, the transdermal route of administration is generally preferred.

In addition to the methods discussed above, the present invention is directed to a pharmaceutical composition, preferably in unit dose form, comprising noribogaine and one or more opioid antagonists. When administered to a patient, one or more unit doses provide an amount of noribogaine and of opioid antagonist effective to treat drug dependency or to provide analgesia. Noribogaine should generally be present in such compositions at a concentration of between about 0.1 and 20 mg/ml. When either naloxone or naltrexone is used as an opioid antagonist in compositions, they should be present at 0.05 to 0.5 mg for each mg of noribogaine.

The present invention contemplates that the administration of active ingredients will be accomplished by any systemic route which is convenient and readily accessible to the attending physician. While all of the various conventional routes of administration are contemplated (*e.g.*, transdermal, intranasal, intramuscular, subcutaneous, intravenous, vaginal, rectal, buccal and oral), the preferred route of administration is transdermally.

The present invention further contemplates the use of noribogaine as an adjunct to conventional drug withdrawal therapy, specifically providing for the administration of noribogaine concomitantly with one or more opioid antagonists. "Concomitant"administration refers to the administration of the two agents (*i.e.*, noribogaine and an opioid antagonist) in any manner in which the pharmacological effects of both are manifest in the patient at the same time. Thus, concomitant administration does not require that a single pharmaceutical

composition, the same dosage form, or even the same route of administration be used for administration of both noribogaine and opioid antagonist or that the two agents be administered at precisely the same time. However, concomitant administration will be accomplished most conveniently by the same dosage form and the same route of administration, at substantially the same time. Obviously, such administration most advantageously proceeds by delivering both active ingredients simultaneously in a novel pharmaceutical composition in accordance with the present invention.

Pharmaceutical compositions in accordance with the invention are prepared by conventional means using methods known in the art. For example, there are known in the art methods for the preparation of opioid antagonist pharmaceutical compositions fully adaptable to the preparation of compositions of both noribogaine and opioid antagonists. Solid pharmaceutical compositions are provided in accordance with the present invention in unit dosage form. A unit dosage for a solid pharmaceutical composition refers to the amount of each of the active ingredients which is administered in any one entity. Thus, the unit dosage form of a solid pharmaceutical composition makes reference to a discreet entity (*e.g.*, a capsule, tablet, suppository, or drug-releasing device), one or more of which entities contains an appropriate dosage for a single administration.

Accordingly, solid pharmaceutical compositions in accordance with the invention are adaptable to provide administration by transdermal, intranasal, oral, vaginal, rectal, and buccal routes. However, for parenteral routes (*e.g.*, subcutaneous, intravenous, and intraarterial) novel liquid pharmaceutical compositions in accordance with the present invention are provided. Also provided are novel liquid pharmaceutical compositions suitable for oral administration (*e.g.*, syrups and elixirs). Each of these pharmaceutical compositions is prepared by methods known in the art.

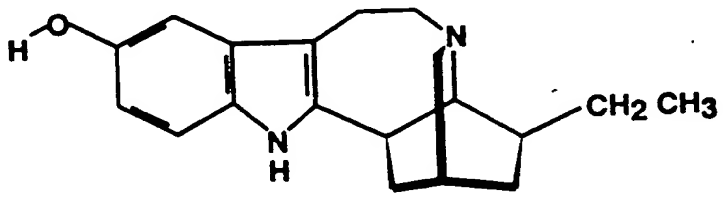
Brief Description of the Figures

Figure 1 (panels A and B): Panel A shows the stimulation of [^{35}S]GTPγS binding to rat thalamic membranes by various concentrations of noribogaine (■) and ibogaine (●). Results are expressed as percent maximal stimulation (defined by 10 μM DAMGO). Panel B shows the inhibitory shift of noribogaine-stimulated [^{35}S]GTPγS binding by naloxone (0.1 μM).

Detailed Description of the Invention

Noribogaine, a metabolite of ibogaine, has properties that are well suited to the treatment of pain and to the withdrawal symptoms associated with drug dependency or abuse. In particular, it has been discovered that noribogaine binds to two classes of opioid receptors that have been associated with pain relief, the μ and κ receptors. In the case of the μ-type receptors, it appears that noribogaine acts as a full opiate agonist. In addition, noribogaine elevates brain serotonin levels by blocking synaptic reuptake. It is believed that such levels (as well as ligand interactions at the μ and κ opiate receptors) play a role in the anxiety and drug cravings experienced by addicts during withdrawal.

Noribogaine is synthesized by the O-demethylation of ibogaine. This may be accomplished, for example, by reacting ibogaine with boron tribromide/methylene chloride at room temperature and then purifying the product using known procedures. At present, noribogaine may also be obtained from the National Institute on Drug Abuse (Rockville, MD). The compound has the following structure:



Chemical Form of Noribogaine

The present invention is not limited to any particular chemical form of noribogaine and the drug may be given to patients either as a free base or as a pharmaceutically acceptable acid addition salt. In the latter case, the hydrochloride salt is generally preferred, but other salts derived from organic or inorganic acids may also be used. Examples of such acids include, without limitation, hydrobromic acid, phosphoric acid, sulfuric acid, methane sulfonic acid, phosphorous acid, nitric acid, perchloric acid, acetic acid, tartaric acid, lactic acid, succinic acid, citric acid, malic acid, maleic acid, aconitic acid, salicylic acid, thalic acid, embonic acid, enanthic acid, and the like. As discussed above, noribogaine itself may be formed by the O-demethylation of ibogaine which, in turn, may be synthesized by methods known in the art (*see e.g.*, Huffman, *et al.*, *J.Org. Chem.* *50*:1460 (1985)).

Preferred Dosage Forms and Route of Administration

As noted above, any route of administration and dosage form is compatible with the treatments discussed above and noribogaine may be administered as either the sole active agent or in combination with other therapeutically active drugs. In this regard, it is preferred that pharmaceutical compositions, especially those used in the treatment of drug addiction or abuse, contain one or more opioid antagonists. Although compositions suitable for oral delivery will probably be used most frequently, other routes that may be used include peroral, internal, pulmonary, rectal, nasal, vaginal, lingual, intravenous, intraarterial, intramuscular, intraperitoneal, intracutaneous and subcutaneous routes. Especially preferred is the transdermal route of delivery in which drug is applied as part of a cream, gel or, preferably, patch (for examples of transdermal formulations, see U.S. 4,806,341; 5,149,538; and 4,626,539). Other dosage forms include tablets, capsules, pills, powders, aerosols, suppositories, parenterals, and oral liquids, including suspensions, solutions and emulsions. Sustained release dosage forms may also be used. All dosage forms may be prepared using methods that are standard in the art (*see e.g.*, Remington's Pharmaceutical Sciences, 16th ed., A. Oslo editor, Easton PA 1980)).

Noribogaine is preferably used in conjunction with any of the vehicles and excipients commonly employed in pharmaceutical preparations, *e.g.*, talc, gum arabic, lactose, starch, magnesium stearate, cocoa butter, aqueous or non-aqueous solvents, oils, paraffin derivatives, glycols, etc. Coloring and flavoring agents may also be added to preparations, particularly to those for oral administration. Solutions can be prepared using water or physiologically compatible organic solvents such as ethanol, 1,2-propylene glycol, polyglycols, dimethylsulfoxide, fatty alcohols, triglycerides, partial esters of glycerine and the like. Parenteral compositions containing noribogaine may be prepared using conventional techniques that may include sterile isotonic saline, water, 1,3-butanediol, ethanol, 1,2-propylene glycol, polyglycols mixed with water, Ringer's solution, etc.

When formulating compositions containing noribogaine in combination with an opioid antagonist, the preferred antagonist will be naloxone, naltrexone or nalorphine. These agents are commercially available and have been approved for the treatment of opioid withdrawal. In general, noribogaine or a pharmaceutically acceptable salt of noribogaine should be present in the pharmaceutical compositions at a concentration of between 0.1 and 20 mg/ml. Naloxone,

naltrexone, or nalorphine should preferably be present at about 0.05 to about 0.5 mg for each mg of noribogaine. The antagonist may be added in any chemical form which is stable in the particular formulation being prepared.

Method of Treatment

Patients will be administered noribogaine or a composition containing noribogaine together with opioid antagonist, either for the treatment of pain or for the treatment of drug dependency or abuse. In either case, dosage will be selected to reduce or eliminate one or more of the symptoms experienced by the patient. Thus, when noribogaine is being administered as an analgesic, sufficient drug should be given to reduce or eliminate the patient's pain. In the case of drug withdrawal, noribogaine should be given at a dosage sufficient to reduce symptoms commonly associated this process, for example, headache and muscular pain, and preferably at a dosage sufficient to also reduce drug cravings. For both treatments, daily dosage will typically be between 0.1 mg and 100 mg of noribogaine per kg of patient body weight and preferably between 1 mg and 30 per kg of patient body weight. Dosage may be provided in single or divided doses. These dosages are simply guidelines and the actual dose selected for an individual patient will be determined by the attending physician based upon clinical conditions and using methods well known in the art. Compositions may be provided in either a single or multiple dosage regimen, (*e.g.*, a patient may take 3 mg of a noribogaine composition orally three times a day). Alternatively, drug may be administered in an essentially continuous manner using a transdermal preparation or patch.

When noribogaine is used in the treatment of pain, administration may be required on a long term basis and the drug may be taken in a prescribed regimen (as discussed above) or as needed by the patient. Long term treatment may also be necessary in the treating patients for drug dependency or abuse. Sustained release dosage forms or transdermal patches are generally preferred in treating these patents.

Advantages

One of the main advantages of noribogaine is that it is not habit forming. Thus, pain relief can be accomplished without the risk of dependence associated with the chronic use of narcotics. Similarly, patients treated for drug dependence or abuse may be given noribogaine

without the abuse/dependence problems presented by treatment with agents such as methadone. In fact, patients participating in drug substitution programs may want to use noribogaine to taper off the substitute. Also, by alleviating some of the worst aspects of the drug withdrawal process, noribogaine should be a form of therapy that poeple dependent upon, or abusing, drugs will find acceptable.

Examples

Noribogaine-stimulated [^{35}S]GTPγS binding to rat thalamic membranes was used to measure receptor activation of G proteins and results are shown in Figure 1 and Table 1. The percent maximal stimulation (10 μM DAMGO, EC_{50} = 7.4 +/- 0.1 nM) of [^{35}S]GTPγS binding stimulated by noribogaine was determined in the presence of an excess of GDP. The EC_{50} value for noribogaine-stimulated binding was 0.324 +/- 0.015 μM. In contrast, ibogaine caused a weak stimulation of [^{35}S]GTPγS binding even at concentrations above 100 μM. Noribogaine - stimulated binding was blocked in the presence of naloxone (competitive antagonist, EC_{50} = 35 +/- 1.8 μM), demonstrating further that the effect of noribogaine was μ-receptor mediated. The rightward shift of the concentration/effect relationship of noribogaine-stimulated binding with increasing concentration of naloxone was similar to that measured for DAMGO in the presence of competitive antagonist. The level of [^{35}S]GTPγS binding stimulated by noribogaine was in close agreement to the maximal number of [^{35}S]GTPγS binding sites that could be occupied after DAMGO stimulation of G proteins.

Taken together, these results demonstrate that noribogaine acts as a full agonist of the μ-opioid receptor and that it has efficacy as an antinociceptive agent that can used without the abuse liability inherent opiates. Results also indicate that noribogaine may effectively be used, either alone or in conjunction with an opioid antagonist, in the treatment of drug addition.

Table 1: Stimulation of [^{35}S]GTPγS Binding to Rat (Sprague Dawley) Thalamic Membranes by Opioid Agonists of Varying Efficacy

Drug	[^{35}S]GTPγS Binding EC_{50}(nM)
Buprenorphine	0.7 ± 0.1
DAMGO	7.4 ± 0.1
Morphine	52 ± 6.3
Noribogaine	324 ± 15.5
Naloxone	NE
Buprenorphine + Naloxone	301 ± 44
DAMGO + Naloxone	2,230 ± 131
Morphine + Naloxone	26,000 ± 842
Noribogaine + Naloxone	236,000 ± 3,410

Values are means ± S.E. from three or more separate experiments. EC_{50} = concentration of drug producing half maximal stimulation of binding.

All references cited herein are fully incorporated by reference. Having now fully described in the invention, it will be understood by those of skill and the art that the invention may be practiced within a wide and equivalent range of conditions, perimeters and the like without effecting the spirit or scope of the invention or any embodiments thereof.